

## **1. PUBLIC HEALTH STATEMENT**

This public health statement tells you about polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs) and the effects of exposure.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal cleanup activities. PBBs have been found in at least 9 of the 1,613 current or former NPL sites. PBDEs have not been identified in any of the 1,613 current or former NPL sites. However, the total number of NPL sites evaluated for these substances is not known. As more sites are evaluated, the sites at which PBBs are found may increase. This information is important because exposure to PBBs may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You are exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact.

If you are exposed to PBBs or PBDEs, many factors determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with them. You must also consider the other chemicals you're exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

### **1.1 WHAT ARE PBBs AND PBDEs?**

PBBs and PBDEs are chemicals that are added to plastics used in a variety of consumer products, such as computer monitors, televisions, textiles, and plastic foams, to make them difficult to burn. Because they are mixed into plastics rather than binding to them, they are able to leave the plastic and find their way into the environment. Commercial production of PBBs and PBDEs began in the 1970s. Manufacture of PBBs was discontinued in the United States in

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1976, while production of PBDEs has continued to the present. Concern regarding PBBs is mainly related to exposures resulting from an agriculture contamination episode that occurred in Michigan over a 10-month period of 1973–1974. Concern for the health effects of PBDEs has increased in recent years because these chemicals are found widely in the environment at concentrations that keep increasing.

PBBs and PBDEs are similar but not identical compounds, and comprise two distinct groups of synthetic organic chemicals. There are no known natural sources of these compounds in the environment. PBBs and PBDEs are solids and are colorless to off-white. Some PBDEs are volatile and may exist as a vapor in air. Both PBBs and PBDEs enter the environment as mixtures containing a variety of individual brominated biphenyl (for PBBs) or brominated diphenyl ether (for PBDEs) components, known as congeners. Some commercial PBB mixtures are known in the United States by their industrial trade name, Firemaster, while commercial PBDE mixtures are known by their industrial trade names, Bromkal, Tardex, and Saytex. While PBBs are no longer used in North America because of the agriculture contamination episode that occurred in Michigan in 1973–1974, PBDEs are still produced and widely used. More information on the physical properties and uses of PBBs and PBDEs can be found in Chapters 4 and 5.

## **1.2 WHAT HAPPENS TO PBBs AND PBDEs WHEN THEY ENTER THE ENVIRONMENT?**

In the past, PBBs entered the air, water, and soil during their manufacture and use. In addition, in lower Michigan in 1973, animal feed was accidentally mixed with 500–1,000 pounds of PBBs. This contamination of the feed/food chain resulted in the contamination of millions of farm animals and humans living in Michigan at this time. PBBs entered the environment during the disposal of animal feed and animal products that were contaminated during the agriculture contamination episode. PBBs entered the environment when PBB-containing wastes generated during their manufacture and use were disposed in waste sites. Small quantities of PBBs also entered the environment from accidental spills during transport. PBBs are no longer manufactured in North America, but very small amounts of PBBs may be released into the

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environment from poorly maintained hazardous waste sites and improper incineration of plastics that contain PBBs.

PBDEs enter air, water, and soil during their manufacture and use in consumer products. When solid PBDEs are suspended in air, they can be present as particles. They eventually return to land or water by settling and washing out by snow and rainwater. Chemical reactions with sunlight may reduce the levels of PBDEs in air. However, it is not yet possible to say how long PBDEs remain in the air. PBDEs do not dissolve easily in water and therefore, high levels of PBDEs are not found in water. The small amounts of PBDEs that do occur in water stick to particles and eventually settle at the bottom. Sediments at the bottom of bodies of water, such as lakes and rivers, generally act as reservoirs for PBDEs, and PBDEs can remain there for years. Some PBDEs in water may build up in fish. In general, the breakdown of PBDEs in soil is very slow, so they may remain in soil for several years. PBDEs bind strongly to soil and do not usually spread deep into soil with rainwater.

More information about what happens to PBBs and PBDEs in the environment can be found in Chapter 6.

### **1.3 HOW MIGHT I BE EXPOSED TO PBBs AND PBDEs?**

PBBs are no longer produced or used in the United States. Thus, the general population exposure to PBBs will only be from past releases. For people residing in the lower peninsula of Michigan, especially near PBB contaminated areas, exposure to PBBs may still be occurring today. However, environmental levels have decreased since the 1970s and current exposure, if any, will be at low levels. For other regions of the United States, the levels of exposure will either be very low or none.

Measured data in air, water, soil, and food, as well as body burden data (blood, urine, breast milk, and body fat), indicate that the overwhelming majority of people within the state of Michigan who were exposed to PBBs received very low levels of PBBs. The body levels due to exposure were slightly higher for people living in the lower peninsula of Michigan and highest

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among farm populations living on contaminated dairy farms. Consumption of contaminated meat and dairy products caused the higher levels of PBBs in the body. Monitoring of the workplace environment and body burden of workers indicated that those in PBB industries were exposed to higher levels of PBBs than the general population. These workers were exposed to PBBs by breathing contaminated workplace air and by skin contact with PBBs. Occupational exposure also could have occurred from the incineration of materials containing PBBs. Exposure in workplaces is no longer likely because PBBs are no longer manufactured. People who live near hazardous waste sites that contain PBBs may be exposed primarily by breathing air that contains PBBs.

PBDEs are still produced and used in the United States. PBDEs are found throughout the environment and are measured at low levels in air, sediments, animals, and food. Body burden data (blood, breast milk, and body fat) indicate that most people are exposed to low levels of PBDEs. People are exposed to PBDEs by breathing air and eating food that contain PBDEs. In the United States, the concentration of PBDEs in outdoor air ranges from 2 to 77 trillionths of a gram per cubic meter (or  $\text{pg}/\text{m}^3$ ), which indicates low levels of exposure to the general population. Indoor air concentrations of PBDEs in lecture halls, computerized indoor environments, and rooms with other electronic devices, such as televisions, also have low levels of PBDEs. Workers involved in the production and manufacture of PBDE-containing products are exposed to higher concentrations of PBDEs. Occupational exposure can also occur in confined workplaces where plastic and foam products are recycled, and computers are repaired. People who live near hazardous waste sites may be exposed to PBDEs by breathing contaminated air.

More information about exposure to PBBs and PBDEs can be found in Chapter 6.

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**1.4 HOW CAN PBBs AND PBDEs ENTER AND LEAVE MY BODY?**

If you breathe air that contains PBBs or PBDEs, or swallow food, water, or soil contaminated with PBBs or PBDEs, they can enter your body through your lungs and stomach and pass into the bloodstream. It is not known how much of the PBBs and PBDEs will pass into the blood from the lungs, although most will probably pass into the blood from the stomach and intestines. Also, if you touch soil containing PBBs or PBDEs, which could happen at a hazardous waste site, it is possible that some of the PBBs and PBDEs could pass through your skin into the bloodstream. However, it is not known how fast PBBs and PBDEs enter the blood from the lungs, stomach, or skin. The most important current source of PBBs is not known because PBBs are no longer produced and used in North America, and are rarely found in air and drinking water away from production plants and contaminated sites. The main source of exposure to PBDEs may be the diet, particularly foods with high fat content such as fatty fish. PBDEs have been detected in air samples, indicating that the general population can also be exposed by inhalation. Once PBBs and PBDEs are in your body, they can change into breakdown products called metabolites, some of which might be harmful. Some metabolites and some unchanged PBBs and PBDEs may leave your body, mainly in the feces and in very small amounts in the urine, within a few days. Other unchanged PBBs and PBDEs may stay in your body for many years. PBBs and PBDEs are stored mainly in your body fat, tend to concentrate in breast milk fat, and can enter the bodies of children through breast feeding. PBBs and PBDEs also can enter the bodies of unborn babies through the placenta. More information on how PBBs and PBDEs can enter and leave your body can be found in Chapter 3.

**1.5 HOW CAN PBBs AND PBDEs AFFECT MY HEALTH?**

To protect the public from the harmful effects of toxic chemicals and to find ways to treat people who have been harmed, scientists use many tests.

One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body; for some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory

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animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals, and scientists must comply with strict animal care guidelines.

Much of what is known about the health effects of PBBs in people comes from studies of ingestion in Michigan in the early-to-mid 1970s, where feed for farm animals was accidentally contaminated with a fire retardant containing PBBs. People were exposed to PBBs for several months when they ate meat, milk, and eggs from the contaminated animals. After news of the contamination episode became widespread, many Michigan residents complained of various health problems, including nausea, abdominal pain, loss of appetite, joint pain, fatigue, and weakness. However, it could not be clearly established that any of the problems were caused by eating the food contaminated with PBBs. PBBs also did not cause any definite changes in the livers or immune systems of the Michigan residents. However, some people who ate the contaminated food developed skin disorders, such as acne and hair loss. It is likely that PBBs caused the skin problems because other chemicals similar to PBBs also cause these effects. Workers who were exposed to PBBs for a few days to months by breathing and skin contact also developed acne, although not all persons exposed to PBBs developed acne. Nothing is known about the health of people who are exposed to low levels of PBBs for long periods by eating, breathing, or skin contact.

Laboratory animals fed PBBs had body weight loss, skin disorders, and nervous system effects, and their livers, kidneys, thyroid glands, and immune systems were seriously injured. Some animals fed high amounts died. PBBs also caused birth defects in animals, but it is not known for sure whether PBBs make males or females infertile. Most of the effects in animals occurred after they ate large amounts of PBBs for short periods or smaller amounts for several weeks or months. In a lifetime study in rats and mice treated orally with PBBs at doses higher than those expected from environmental exposure, body weight loss and effects on the livers, kidneys, and thyroid glands were observed. A few studies tested animals exposed to PBBs by skin contact. These animals had injuries to the liver and skin. Only one study tested animals exposed to PBBs by breathing, and no health effects were observed.

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It is not definitely known if PBBs caused or will cause cancer in people who ate food contaminated with PBBs. Rats developed cancer in their livers after eating a large amount of a PBB mixture only once. The offspring of exposed rats also developed cancer in their livers after eating a large amount of the same PBB mixture only once. Liver cancer also developed in rats and mice that ate smaller amounts of the PBB mixture for several months. Mice that had skin contact with a small amount of a PBB mixture for several months did not develop skin cancer. There are no cancer studies in animals that breathed PBBs. Based on the cancer in animals, the National Toxicology Program (NTP) of the Department of Health and Human Services (DHHS) determined that PBBs may reasonably be anticipated to be carcinogens. Similarly, the International Agency for Research on Cancer (IARC) has determined that PBBs are possibly carcinogenic to humans. The EPA has not classified the carcinogenicity of PBBs.

The health effects of PBDEs are not as well studied as for PBBs and practically all of the information is from studies in laboratory animals. No definite information is known on effects of PBDEs in people. Rats and mice that ate food containing moderate amounts of PBDEs for short periods of time had mainly thyroid effects, and those that ate smaller amounts over several weeks or months developed effects in the liver as well as in the thyroid. Preliminary findings from short-term animal studies suggest that PBDEs might cause reduced immune system function and neurobehavioral alterations. Behavioral changes were observed in young animals and might be related to effects on the thyroid, because development of the nervous system is dependent on thyroid hormones. More studies are needed to determine if PBDEs can impair reproduction, but PBDEs are not known to cause birth defects. Animals that were exposed to PBDEs by skin contact showed signs of dermal irritation only when the skin was previously scratched.

It is unclear if PBDEs can cause cancer in people, although liver tumors developed in rats and mice that ate decabromodiphenyl ether throughout their lives. Decabromodiphenyl ether is one type of PBDEs; other kinds of PBDEs have not yet been tested for cancer. Based on the evidence for cancer in animals, decabromodiphenyl ether is classified as a possible human carcinogen by EPA. Neither DHHS nor IARC have classified the carcinogenicity of any PBDEs.

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It is not known whether the effects found in animals exposed to PBBs and PBDEs would also occur in people exposed in the same way. The amounts of PBBs and PBDEs that caused health effects in animals are much greater than levels of PBBs and PBDEs normally found in the environment or as yet found in people. Long-term exposure to these chemicals has a greater potential to cause health effects than short-term exposure to low levels because of their tendency to build up in your body over many years. More information on how PBBs and PBDEs can affect your health can be found in Chapter 3.

**1.6 HOW CAN PBBs AND PBDEs AFFECT CHILDREN?**

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans.

Children are exposed to PBBs and PBDEs in generally the same way as are adults, mainly by eating contaminated food. Because of their smaller weight, children's intake of PBBs and PBDEs per kilogram of body weight may be greater than that of adults. The most likely way that infants will be exposed is from breast milk that contains PBBs and PBDEs, although fetuses in the womb are also exposed. Children who live near hazardous waste sites might accidentally eat some PBBs or PBDEs through hand-to-mouth behavior, such as by putting dirty hands or other soil/dirt covered objects in their mouths, or eating without washing their hands. Some children also eat dirt on purpose; this behavior is called pica. It is also possible that children could be exposed to PBDEs following transport of the chemical on clothing from the parent's workplace to the home (PBBs are no longer being produced).

Some information on health effects of PBBs in children is available from studies of the Michigan contamination episode. Symptoms of ill health were not associated with increased exposure to PBBs and general neurological examinations did not show any abnormalities. More detailed studies of physical and neuropsychological development showed no effects that were clearly related to PBBs among Michigan children exposed during the episode. Neurobehavioral alterations have been found in animals that were exposed to PBBs in the womb and by nursing. Animal studies also found that exposure to PBBs during pregnancy and/or lactation caused



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changes in thyroid hormone levels in the newborn animals and, at high doses, increases in prenatal death and structural birth defects. Thyroid and neurobehavioral alterations also occurred in newborn babies of animals that were exposed to PBDEs during pregnancy and lactation, further indicating that these are possible effects of concern in children exposed to PBBs or PBDEs.

As indicated above, children can be exposed to PBBs and PBDEs both prenatally and from breast milk. PBBs and PBDEs are stored in the mother's body and can be released during pregnancy, cross the placenta, and enter fetal tissues. Because PBBs and PBDEs dissolve readily in fat, they can accumulate in breast milk fat and be transferred to babies and young children. PBBs and PBDEs have been found in breast milk; however, in most cases, the benefits of breast-feeding outweigh any risks from exposure in mother's milk. You should consult your health care provider if you have any concerns about PBBs or PBDEs and breast feeding. Because the nervous system and thyroid are still developing in the fetus and child, the effects of PBBs and PBDEs on these target systems might be more profound after exposure during the prenatal and neonatal periods, which could make fetuses and children more susceptible to PBBs and PBDEs than adults.

More information regarding children's health and exposure to PBBs and PBDEs can be found in Chapter 3 (Section 3.7).

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**1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO PBBs AND PBDEs?**

If your doctor finds that you have been exposed to significant amounts of PBBs or PBDEs, ask whether your children might also be exposed. Your doctor might need to ask your state health department to investigate.

Since PBBs are no longer produced or used, the risk of exposure to these compounds is limited. PBDEs are currently in widespread production and use. You and your children may be exposed to PBBs and PBDEs by eating fish or wildlife caught from contaminated locations. Children who live near hazardous waste sites should be discouraged from playing in the dirt near these sites because they could contain PBBs or PBDEs. Children should also be discouraged from eating the dirt, and careful handwashing practices should be followed.

As mentioned in Section 1.3, workplace exposure to PBDEs can occur during their production and the manufacture of PBDE-containing plastic products. Workers involved in recycling plastic products, computer repair in confined workplaces can also be occupationally exposed to PBDEs. If you are exposed to PBDEs while at work, it may be possible to carry them home on your clothes or body. Your occupational health and safety officer at work can tell you whether the products you work with may contain PBDEs and are likely to be carried home. If this is the case, you should shower and change clothing before leaving work, and your work clothes should be kept separate from other clothes and laundered separately.

**1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO PBBs AND PBDEs?**

There are tests to determine whether PBBs and PBDEs are in the blood, body fat, and breast milk. These are not regular or routine clinical tests, such as the one for cholesterol, but could be ordered by a doctor to detect PBBs and PBDEs in people exposed to them in the environment and at work. If your PBB and PBDE levels are higher than the normal levels, this will show that you have been exposed to high levels of the chemicals. However, these measurements cannot

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determine the exact amount or type of PBBs or PBDEs that you have been exposed to, or how long you have been exposed. Although these tests can indicate whether you have been exposed to PBBs and PBDEs to a greater extent than the general population, they do not predict whether you will develop harmful health effects. Blood tests are the easiest, safest, and probably the best method for detecting recent exposures to large amounts of PBBs and PBDEs. Results of such tests should be reviewed and carefully interpreted by physicians with a background in environmental and occupational medicine. Although exposures to PBBs have been of greatest concern in Michigan as explained in Section 1.3, nearly everyone has been exposed to PBDEs because they are found throughout the environment, and the general population is therefore more likely to have detectable amounts of PBDEs in their blood, fat, and breast milk. Recent studies have shown that PBDE levels in the general population continue to rise, whereas levels of PBBs have declined since the 1970s. More information on tests used to determine whether you have been exposed to PBBs or PBDEs can be found in Chapter 3 (Section 3.11) and Chapter 7 (Section 7.1).

### **1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?**

The federal government develops regulations and recommendations to protect public health. Regulations can be enforced by law. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA).

Recommendations provide valuable guidelines to protect public health but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH).

Regulations and recommendations can be expressed in not-to-exceed levels in air, water, soil, or food that are usually based on levels that affect animals; then they are adjusted to help protect people. Sometimes these not-to-exceed levels differ among federal organizations because of

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different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors.

Recommendations and regulations are also periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for PBBs include the following:

There are no federal guidelines or recommendations for protecting human health from exposure to PBBs.

EPA requires that companies that transport, store, or dispose of *p*-bromodiphenyl ether (a particular PBDE compound) follow the rules and regulations of the federal hazardous waste management program. EPA also limits the amount of *p*-bromodiphenyl ether put into publicly owned waste water treatment plants. To minimize exposure of people to *p*-bromodiphenyl ether, EPA requires that industry tell the National Response Center each time 100 pounds or more of *p*-bromodiphenyl ether have been released to the environment.

For more information on federal and state regulations and guidelines for PBBs and PBDEs, see Chapter 8.

### 1.10 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department or

Agency for Toxic Substances and Disease Registry  
Division of Toxicology  
1600 Clifton Road NE, Mailstop E-29  
Atlanta, GA 30333  
Web site: <http://www.atsdr.cdc.gov>

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\* Information line and technical assistance

Phone: 1-888-42-ATSDR (1-888-422-8737)

Fax: 1-404-498-0057

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

\* To order toxicological profiles, contact

National Technical Information Service

5285 Port Royal Road

Springfield, VA 22161

Phone: 1-800-553-6847 or 1-703-605-6000

